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# PRECIPITATION CHARACTERISTICS IN THE PALOUSE AREA OF IDAHO AND WASHINGTON

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

# X PRECIPITATION CHARACTERISTICS IN THE PALOUSE AREA OF IDAHO AND WASHINGTON[1]

By

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Knowledge of precipitation characteristics of an area is useful in solving many hydrologic problems. The South Fork Palouse River demonstration project, located in western Latah County, Idaho, and eastern Whitman County, Wash., was started in January 1934 to collect and study precipitation, streamflow, and sediment data. The project was operated by the Soil Conservation Service and its predecessor agency, the Soil Erosion Service. The hydrologic investigations were terminated in June 1940. Data were summarized and published in 1942 as SCS-TP-47, "Hydrologic Studies at the South Fork Palouse River Demonstration Project." A few intermittent records were collected after 1940, and a recording rain and snow gage was in continuous operation from October 1932 to December 1959. A map of the study area with the designation numbers and approximate locations of the precipitation gages is given in figure 1.

This report presents the results of a study of the precipitation records collected. Three characteristics of precipitation are considered: (1) Depth-time distribution of precipitation within a storm, (2) the relation between precipitation depth and areal extent of a storm, and (3) depth-duration-frequency relations.

## PHYSICAL CHARACTERISTICS OF THE STUDY AREA

The South Fork Palouse River demonstration project covered an area of approximately 200 square miles and included the drainage basins of Fourmile Creek, Missouri Flat Creek, and the South Fork Palouse River. A large part of the area consists of rolling to steeply rolling topography with a range in elevation from 2,300 feet mean sea level at the outlet of Fourmile Creek to 5,100 feet on the peak of the Thatuna Mountain Range northeast of Moscow, Idaho. The average elevation is approximately 2,700 feet. Streams rise in the Thatuna Mountain Range, known locally as Moscow Mountains, and flow toward the west to the watershed outlet.

## INSTRUMENTATION

All but one of the recording rain gages were either Fergusson weighing recording rain and snow gages with a 9-inch, weekly, 12-hour chart or Friez reconnaissance recording rain and snow gages with a 3-inch, 24-hour chart. Gage No. 115 was a tipping bucket recording rain and

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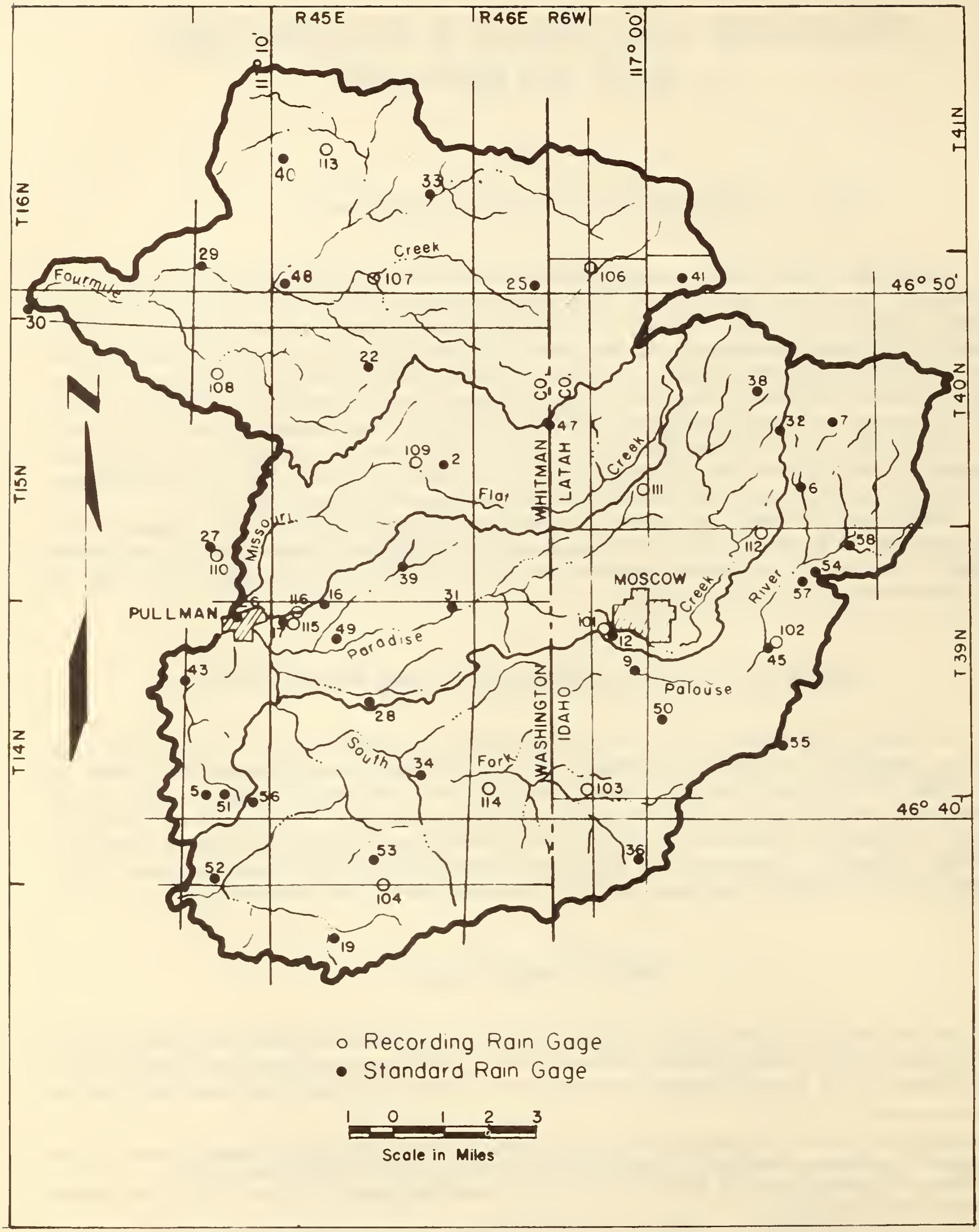

Figure 1.—Map of study area, with the designation numbers and approximate locations of the precipitation gages.

snow gage. The nonrecording gages used on the project were standard Weather Bureau type read by cooperative observers.

## CLIMATE

The climate of the Palouse area is of the semiarid plateau type. The average annual precipitation ranges from approximately 21 inches at Pullman and Moscow to about 37 inches at the crest of the Thatuna Range. Approximately 75 percent of the annual precipitation occurs from October through April. The average January temperature in the Pullman-Moscow vicinity is about 28° F., and the average July temperature is about 67°. The recorded temperatures range from 115° F. to -30°. No temperature records are available from locations in the mountains.

Observations in the study area indicate that storms tend to fall into one of two types. The first, and most common, of these is the cyclonic type, which is characterized by fairly low intensity, long duration, and relatively large areal extent. This type can include rain, snow, and mixed rain and snow. The second type is the thunderstorm, characterized by high intensity, short duration, and limited areal extent. Thunderstorms are more apt to occur in the summer months--the season during which atmospheric conditions favor this type.

In this report all storms that occurred from May through September, inclusive, have been arbitrarily classified as "summer type" and those that occurred from October through April as "winter type." Also, a storm was defined as a period of continuous precipitation immediately preceded and followed by a minimum of 3 hours during which no precipitation was recorded.

## PRECIPITATION DEPTH-TIME DISTRIBUTION

From the 27-year record of rain gage No. 110, there were 680 individual precipitation events that met the definition of storm as given here. Of these, 161 were summer-type storms with durations ranging from 4 to 8 hours and 519 were winter-type storms with durations ranging from 4 to 12 hours. Table 1 gives the number of storms of each type and the range of total precipitation for storms of given durations.

Storms with durations greater than 8 hours for the summer type and greater than 12 hours for the winter type were not included in the analysis. Too few storms of these longer durations occurred during the period of record to adequately define the depth-time relation.

Hourly precipitation was tabulated for each storm and computations were made as shown by the example in table 2.

The next step was to determine a representative depth-time distribution for each duration by combining the data from the individual storms. This was done by taking an arithmetical average of the precipitation ratios for each hour of the storms of each duration. Average curves for summer-type and winter-type storms are shown in figure 2, A and B, respectively.

To compare the average distribution curves of the various durations, time was expressed as a ratio to the total storm duration (figure 3, A and B). Individual duration curves were not drawn in figure 3, A and B because all were very close together. Instead, the points were plotted for all durations and maximum and minimum envelope curves were drawn.

TABLE 1.--Summary of storm data, Gage 110, 1933-59.

| Duration, hours | Summer-type storm |  | Winter-type storm |  |
|---|---|---|---|---|
|  | Storms | Total precipitation range | Storms | Total precipitation range |
|  | Number | Inches | Number | Inches |
| 4.................. | 57 | 0.04-0.48 | 132 | 0.04-0.37 |
| 5.................. | 42 | .05- .51 | 88 | .05- .43 |
| 6.................. | 27 | .06-2.47 | 93 | .06- .59 |
| 7.................. | 20 | .09- .67 | 68 | .08- .61 |
| 8.................. | 15 | .15- .83 | 41 | .09- .70 |
| 9.................. | --- | --- | 31 | .10- .85 |
| 10.................. | --- | --- | 25 | .13- .65 |
| 11.................. | --- | --- | 26 | .24-1.05 |
| 12.................. | --- | --- | 15 | .15- .74 |

TABLE 2.--Sample computation of depth-time distribution for Palouse area, storm of Sept. 26-27, 1948

| Time | Hour | Precipitation | Accumulative precipitation | Ratio of accumulative precipitation to storm total |
|---|---|---|---|---|
|  | Number | Inches | Inches |  |
| 9 p.m. .......... | 1 | 0.02 | 0.02 | 0.095 |
| 10 p.m. .......... | 2 | .04 | .06 | .286 |
| 11 p.m. .......... | 3 | .05 | .11 | .524 |
| 12 p.m. .......... | 4 | .06 | .17 | .810 |
| 1 a.m. .......... | 5 | .03 | .20 | .952 |
| 2 a.m. .......... | 6 | .01 | .21 | 1.000 |

This study was an attempt to determine the average, not the extreme, precipitation depth-time distributions. Individual storms deviated widely from the average curves (figure 2, A and B). As expected, in some storms, called "advanced," the major part of the total precipitation came early in the storm and in others, called "delayed," most of the precipitation came later in the storm. Both advanced and delayed storms had precipitation rates at some time during the storm that were greater than the maximum rates of events that more closely followed the average distribution curves. Investigations of individual advanced and delayed storms did not indicate that the higher rates could be attributed to form or amount of precipitation or to variations in temperature. There were both advanced and delayed storms during the period of record that had the following characteristics: (1) much precipitation; (2) little precipitation; (3) entirely rainfall; (4) entirely snowfall; (5) mixture of rain and snow. Apparently the distribution of precipitation within the storm was caused by unmeasured atmospheric conditions. Consequently,

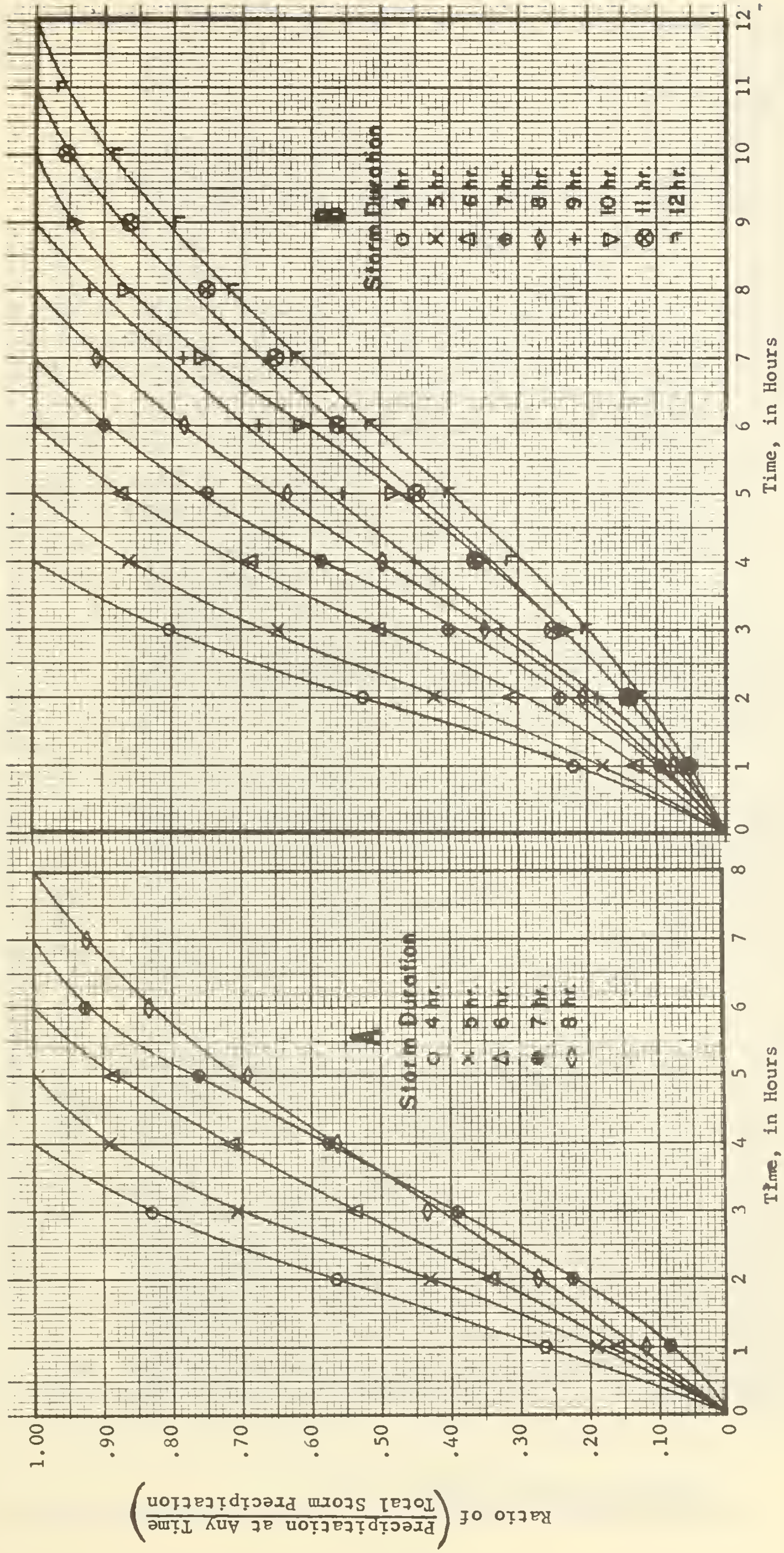

Figure 2.—Average depth-time distribution curves: A. Summer-type storms, B, winter-type storms.

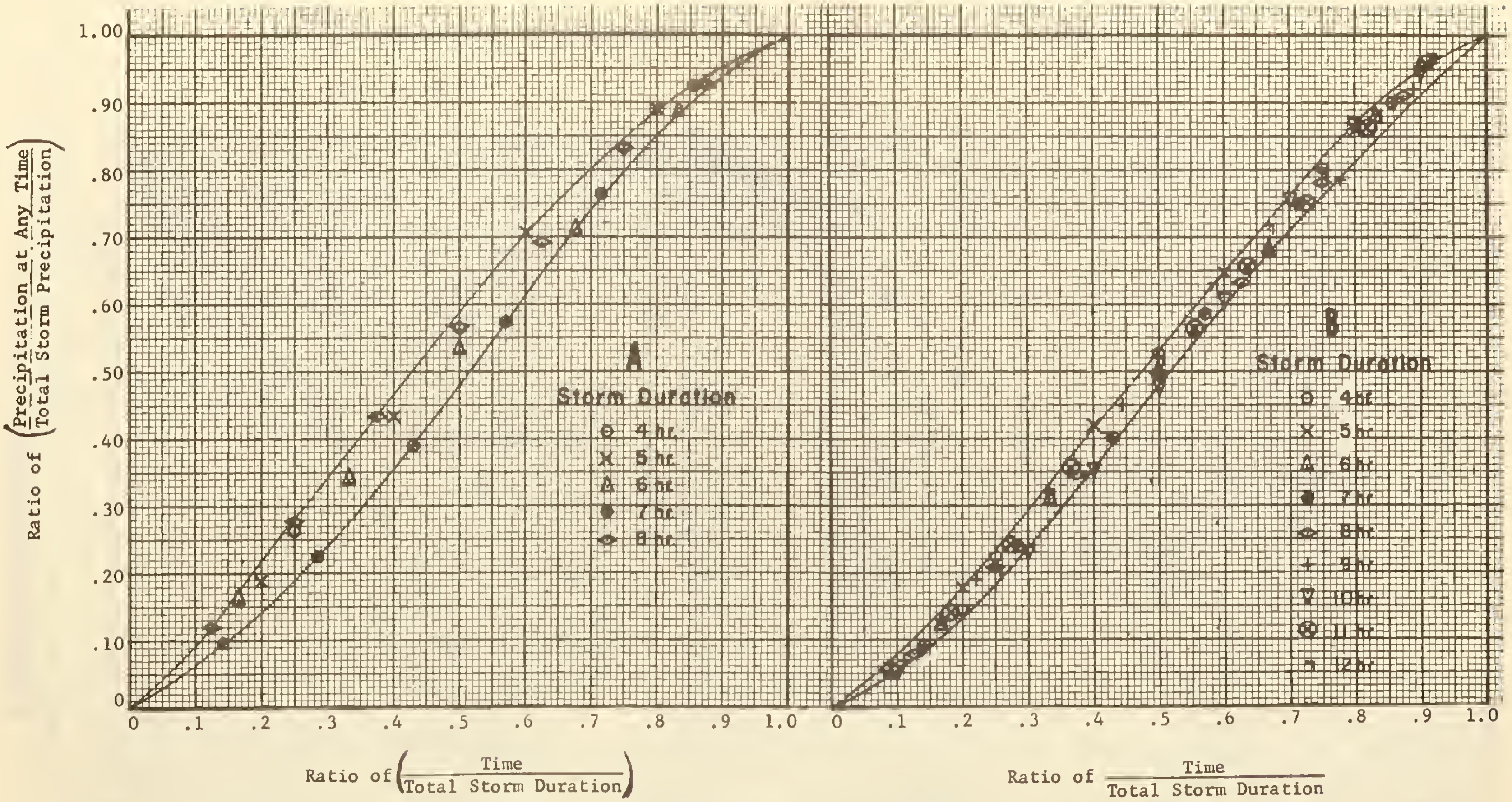

Figure 3.—Average dimensionless depth-time distribution curves: A, Summer-type storms; B, winter-type storms.

no attempt was made to present other than the average precipitation depth-time distribution curves for the several durations.

## PRECIPITATION DEPTH-AREA DISTRIBUTION

Approximately 75 percent of the average annual precipitation in the study area occurs during October through April as the result of frontal-type cyclonic storms. As discussed previously, these storms are characterized by low intensities and long durations.

The precipitation gage network used in the depth-area study consisted of 16 recording gages, with hourly precipitation amounts recorded, and 49 nonrecording gages, with daily amounts recorded. However, the records of many of these gages are intermittent. The period April 1937 to March 1940 was selected for study because 10 recording gages were in operation while during the previous years there were only 3. The more dense network of recording gages made possible a better definition of individual storms that occurred over the entire area.

Twenty-one storms of various durations, precipitation amounts, and seasons were selected for study. Of these, eight occurred during the winter, eight during the spring, four during the fall, and one during the summer. There were 6 snowstorms and 15 rainstorms. The maximum recorded amounts of precipitation for each storm ranged from 0.30 to 0.90 inch, and the range in duration was from 5 to 17 hours.

Isohyetal maps were constructed for each storm (figure 4). The area between adjacent isohyets within the watershed boundary was measured by planimeter, and the average watershed precipitation was computed by standard techniques. An example of computation of average precipitation is shown in table 3.

The ratio from the last column of the table was plotted versus the accumulative area on semilogarithmic graph paper. These calculations were made for each of the 21 storms, which were then separated according to the form in which the precipitation occurred. The plotting of the depth-area distribution of the 15 rainstorms and 6 snowstorms is shown in figure 5, A and B, respectively.

Average curves for both rain and snowstorms were computed and plotted (fig. 6). These curves illustrate the distinct difference found in the depth-area distribution of the two types of precipitation. For comparison the Sharp, Fletcher, and Dorroh curves are also shown.[4] The curves indicate that the average snowstorm has a more limited areal coverage than does the average rainstorm.

Five snowstorms and three rainstorms occurred during winter months and one snowstorm and three rainstorms occurred during the fall. The distribution of these individual storms led to the conclusion that the season during which the storm occurred had less effect than whether the precipitation was rain or snow. Likewise, other seasons apparently had no effect on the distribution, as the depth-area distribution values for storms from each season were scattered over the entire range of the graph. Neither the amount nor the duration of the storm had a significant influence on the depth- area distribution. However, there was a slight tendency for the values of the depth-area distribution of storms of longer durations to plot nearer the Sharp curve. That is, the long-duration storms were sometimes more uniform than short duration storms.

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[4] Soil Conservation Service, Engineering Handbook, Hydrology, Sup. A, Sect. 4, Fig. 3. 21-4.

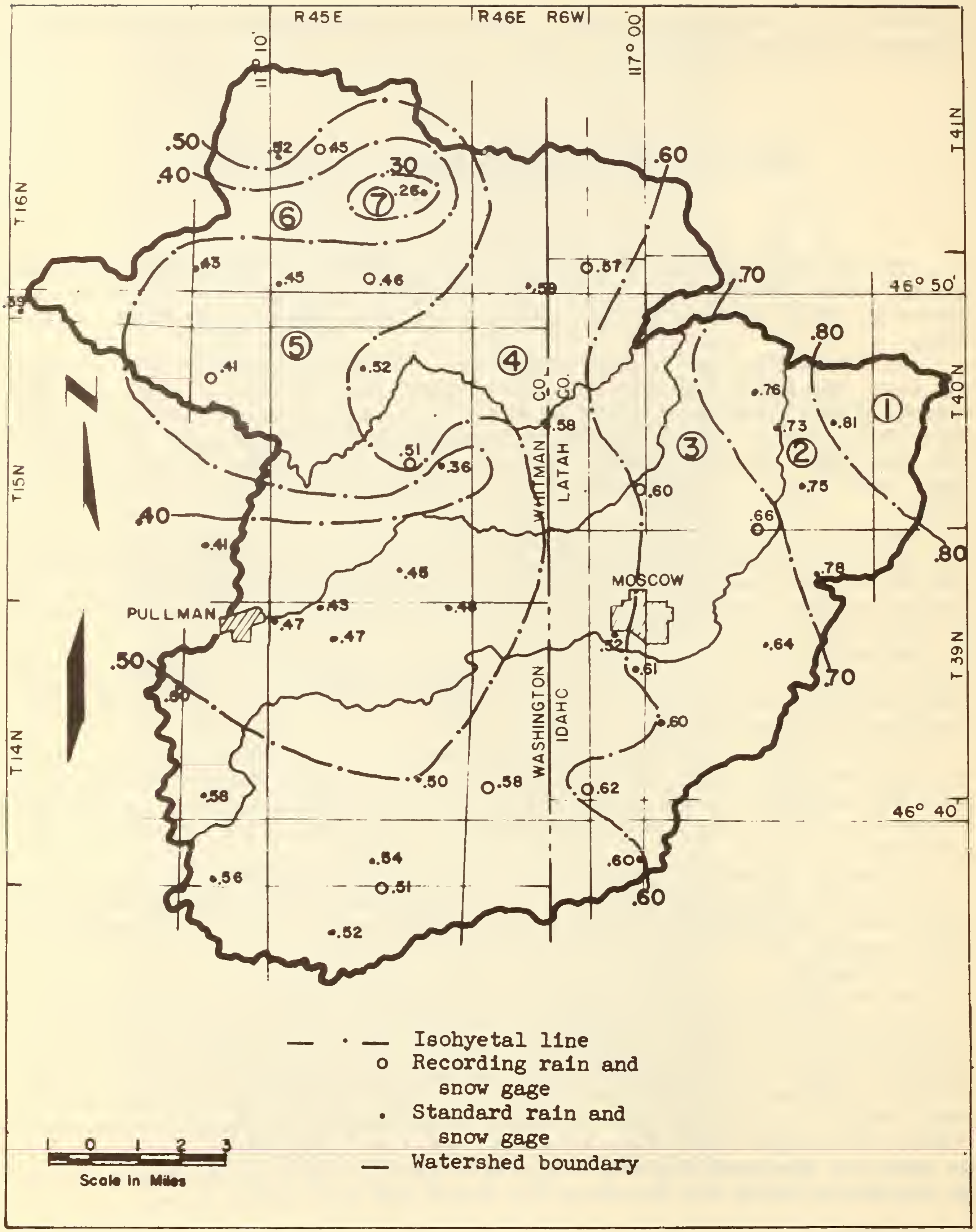

Figure 4.—Isohyetal map for storm of July 3, 1939.

TABLE 3.--Sample computation of average precipitation in Palouse area, storm of July 3, 1939

| Subarea No. | Area | Subarea average precipitation | Summation (area X precipitation) | Accumulative area | Average precipitation | Ratio of average precipitation to maximum point precipitation |
|---|---|---|---|---|---|---|
| | Square miles | Inches | | Square miles | Inches | Inches |
| 1.......... | 6.0 | 0.805 | 4.830 | 6.0 | 0.805 | 0.994 |
| 2.......... | 13.3 | .750 | 14.805 | 19.3 | .767 | .947 |
| 3.......... | 35.2 | .650 | 37.685 | 54.5 | .691 | .853 |
| 4.......... | 85.0 | .550 | 84.435 | 139.5 | .605 | .747 |
| 5.......... | 63.2 | .450 | 112.275 | 202.7 | .554 | .684 |
| 6.......... | 14.1 | .350 | 117.810 | 216.8 | .543 | .670 |
| 7.......... | 1.4 | .280 | 118.202 | 218.2 | .542 | .669 |

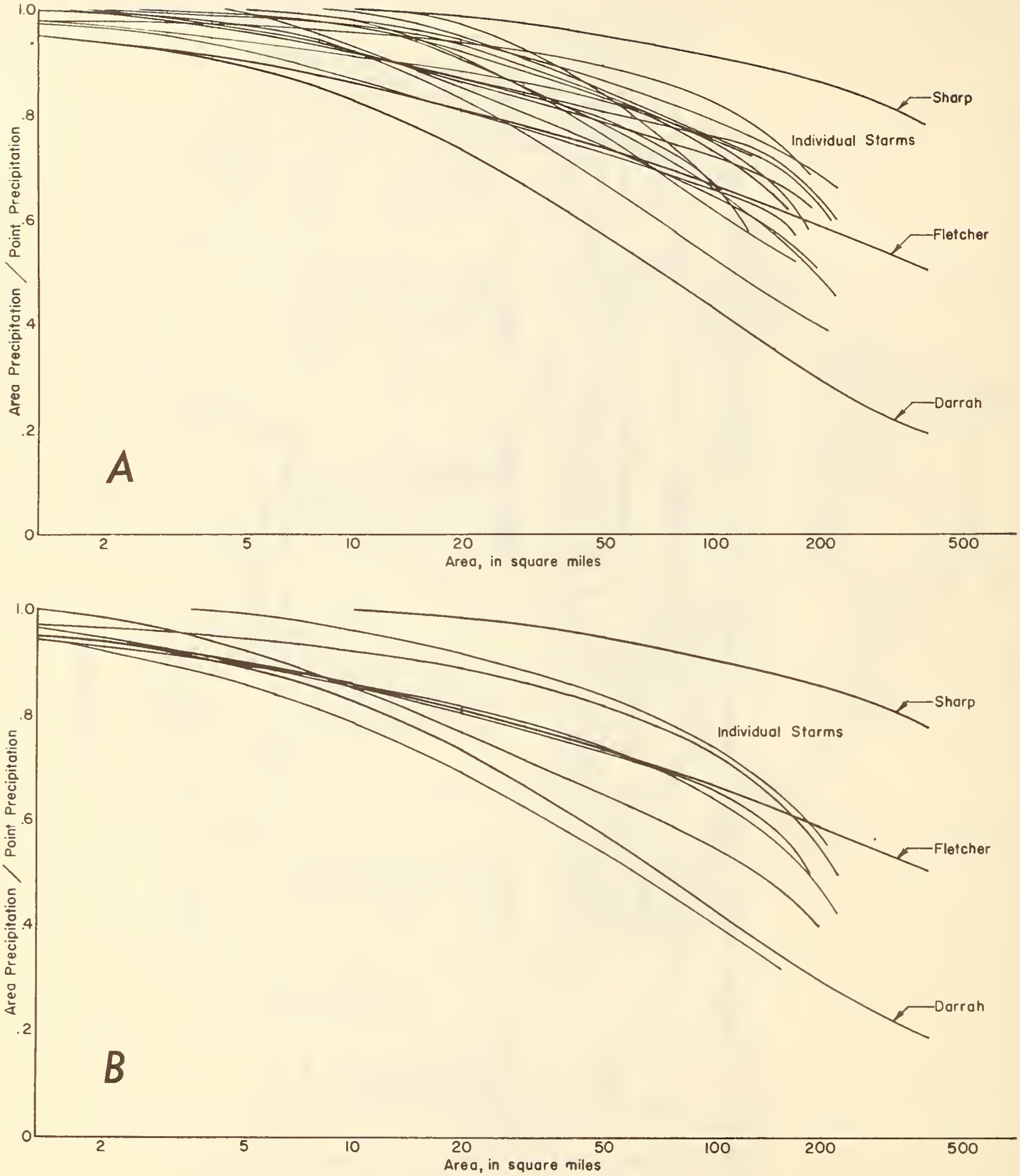

Figure 5.—Depth-area distribution of (A) individual rainstorms and (B) individual snowstorms.

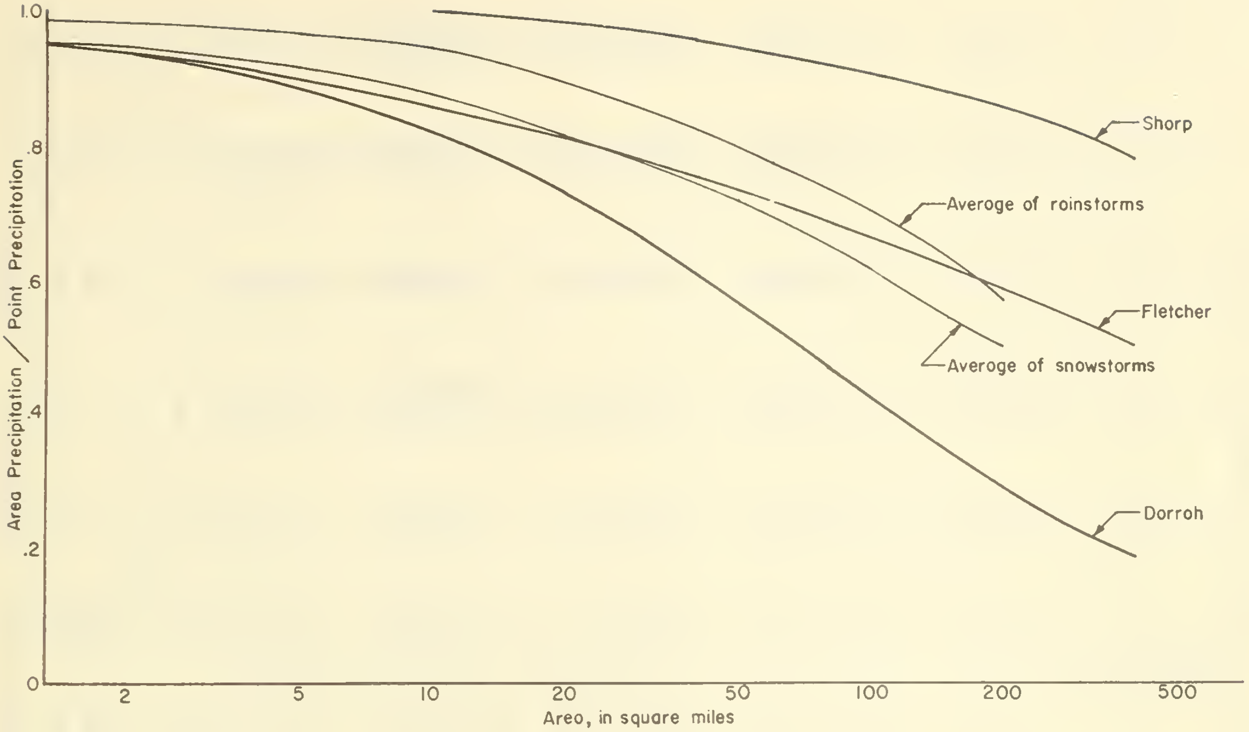

Figure 6.—Average depth-area distribution of rainstorms and snowstorms.

## DEPTH-DURATION-FREQUENCY RELATIONS

The 27-year record of rain gage No. 110 was used in the depth-duration-frequency study. Annual maximum precipitation amounts were tabulated by season and duration of storms (tables 4 and 5). These values are for single storms; they are not amounts recorded within a storm occurrence.

These data were used in the standard Hazen[5] computation method to arrive at a precipitation depth-frequency relation for each duration. The computation method rather than the plotting-position method was used to standardize the procedure and to eliminate any personal bias that might occur in graphically fitting a curve to plotted points. Since the Hazen computation method assumes a straight line or logarithmic-normal graph paper, two points define this line. The 2-year frequency precipitation amount ($P_2$) and the 100-year frequency precipitation amount ($P_{100}$) were the two points selected. Also the ratio of the 100-year to the 2-year frequency amount gives an indication of the slope of the frequency line.

The values of $P_2$ and $P_{100}$ were plotted against duration for summer-type and winter-type storms, as shown in figure 7, A and B, respectively. Smooth curves were drawn through these points, and the ratio of the 100-year to the 2-year frequency precipitation amount was computed for each duration and season from these curves (fig. 8).

The slopes of the frequency curves (fig. 8) of the shorter duration storms are the steeper; this indicates that these storms have the greatest variability. As the duration increases, the

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[5] For a complete discussion of the frequency method used, see: Hazen, Allen. Flood flows, 199 pp., illus. John Wiley & Sons, Inc., New York, 1930.

TABLE 4.--Maximum precipitation of summer-type storms at gage 110, 1933-59

| Year | Duration, hours-- | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 1933........ | 0.21 | 0.21 | 0.49 | 0.49 | 0.49 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| 1934........ | .26 | .51 | .51 | .51 | .51 | .51 | .51 | .51 | .55 | .55 | .55 | 1.66 | 1.66 |
| 1935........ | .25 | .25 | .25 | .25 | .25 | .25 | .25 | .25 | .36 | .36 | .36 | .36 | .36 |
| 1936........ | .31 | .31 | .44 | .44 | .44 | .44 | .44 | .44 | .44 | .44 | .44 | .44 | .44 |
| 1937........ | .33 | .39 | .39 | .67 | .67 | .74 | .74 | .74 | .74 | .74 | .74 | .74 | .74 |
| 1938........ | .32 | .32 | .37 | .42 | .44 | .44 | .44 | .44 | .44 | .44 | .44 | .44 | .44 |
| 1939........ | .15 | .25 | .25 | .25 | .25 | .25 | .25 | .25 | .25 | .42 | .42 | .42 | .42 |
| 1940........ | .48 | .48 | .48 | .48 | .48 | .59 | .59 | .59 | .59 | .59 | .59 | .59 | .80 |
| 1941........ | .35 | .35 | .47 | .47 | .47 | .47 | .47 | .48 | .48 | .48 | 1.06 | 1.06 | 1.06 |
| 1942........ | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 |
| 1943........ | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .37 | .40 | .40 | .40 |
| 1944........ | .45 | .45 | .45 | .45 | .45 | .45 | .45 | .45 | .45 | .45 | .45 | .45 | .45 |
| 1945........ | .43 | .55 | .55 | .55 | .56 | .56 | .56 | .57 | .57 | .57 | .57 | .57 | .57 |
| 1946........ | .41 | .41 | .41 | .45 | .45 | .45 | .45 | .46 | .46 | .48 | .48 | .48 | .48 |
| 1947........ | .42 | .42 | .43 | .43 | .43 | .43 | .49 | .60 | .60 | .86 | .86 | .86 | .86 |
| 1948........ | .28 | .28 | .78 | .78 | .78 | .78 | .78 | .78 | .78 | .78 | .78 | 1.06 | 1.06 |
| 1949........ | .09 | .11 | .11 | .16 | .16 | .61 | .61 | .61 | .82 | .82 | .82 | .82 | .82 |
| 1950........ | .11 | .18 | .18 | .18 | .29 | .29 | .29 | .29 | .29 | .29 | .29 | .51 | .51 |
| 1951........ | .09 | .09 | .26 | .26 | .26 | .44 | .44 | .44 | .44 | .44 | .44 | .44 | .44 |
| 1952........ | .24 | .43 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 | 2.47 |
| 1953........ | .33 | .33 | .64 | .64 | .64 | .64 | .64 | .64 | .64 | .64 | .64 | .64 | .64 |
| 1954........ | .41 | .41 | .41 | .41 | .41 | .41 | .41 | .41 | .71 | .71 | .71 | .71 | .71 |
| 1955........ | .35 | .35 | .39 | .39 | .83 | .83 | .83 | .83 | .83 | .83 | .83 | .83 | .83 |
| 1956........ | .19 | .19 | .76 | .76 | .76 | .79 | .79 | .79 | .79 | .79 | .79 | .79 | 1.08 |
| 1957........ | .38 | .38 | .50 | .50 | .50 | .89 | .89 | .89 | .89 | .89 | .89 | .89 | .89 |
| 1958........ | .28 | .28 | .28 | .34 | .34 | .34 | .83 | .83 | .83 | .83 | .83 | .88 | .88 |
| 1959........ | .20 | .79 | .79 | .79 | .79 | .79 | .79 | .79 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 |

TABLE 5.--Maximum precipitation of winter-type storms at gage 110, 1933-59

| Year | Duration, hours-- | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 1933 | 0.35 | 0.35 | 0.35 | 0.52 | 0.66 | 0.66 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| 1934 | .20 | .33 | .33 | .56 | .56 | .56 | .61 | .61 | .64 | .64 | .64 |
| 1935 | .17 | .17 | .33 | .36 | .36 | .41 | .47 | .92 | .92 | .92 | .92 |
| 1936 | .30 | .30 | .30 | .46 | .46 | .46 | .46 | .81 | .81 | .81 | .81 |
| 1937 | .29 | .42 | .48 | .48 | .48 | .48 | .48 | .48 | .48 | .48 | .48 |
| 1938 | .37 | .37 | .45 | .46 | .46 | .46 | .53 | .53 | .53 | .53 | .54 |
| 1939 | .14 | .38 | .59 | .59 | .59 | .59 | .59 | .59 | .62 | .84 | .84 |
| 1940 | .24 | .29 | .29 | .45 | .45 | .45 | .45 | .48 | .48 | .53 | .53 |
| 1941 | .31 | .43 | .43 | .43 | .43 | .51 | .51 | .51 | .63 | .63 | .63 |
| 1942 | .28 | .34 | .34 | .34 | .70 | .85 | .85 | .85 | .85 | .85 | .85 |
| 1943 | .16 | .18 | .24 | .29 | .52 | .52 | .55 | .61 | .61 | .61 | .65 |
| 1944 | .17 | .17 | .27 | .28 | .34 | .55 | .55 | .55 | .55 | .55 | .55 |
| 1945 | .16 | .16 | .38 | .41 | .41 | .41 | .41 | .41 | .43 | .43 | .43 |
| 1946 | .32 | .32 | .44 | .47 | .47 | .47 | .61 | .61 | .61 | .78 | .78 |
| 1947 | .19 | .21 | .43 | .43 | .43 | .81 | .81 | .81 | .81 | .81 | .81 |
| 1948 | .28 | .28 | .28 | .31 | .54 | .54 | .54 | .85 | .85 | .85 | .88 |
| 1949 | .29 | .29 | .29 | .75 | .75 | .75 | .75 | .75 | .75 | .82 | .82 |
| 1950 | .45 | .45 | .45 | .45 | .45 | .61 | .61 | .61 | .61 | .61 | .61 |
| 1951 | .28 | .28 | .29 | .61 | .61 | .94 | .94 | .94 | .94 | .94 | .94 |
| 1952 | .12 | .15 | .43 | .43 | .43 | .43 | .43 | .43 | .43 | .55 | .55 |
| 1953 | .18 | .18 | .30 | .30 | .48 | .48 | .48 | .57 | 1.19 | 1.19 | 1.19 |
| 1954 | .30 | .30 | .30 | .38 | .52 | .52 | .52 | .52 | .52 | .63 | .63 |
| 1955 | .17 | .36 | .52 | .52 | .52 | .52 | .64 | .64 | .64 | .98 | .98 |
| 1956 | .17 | .21 | .22 | .22 | .61 | .61 | .83 | .83 | .83 | .83 | .83 |
| 1957 | .29 | .29 | .29 | .29 | .29 | .45 | .45 | 1.05 | 1.05 | 1.05 | 1.05 |
| 1958 | .24 | .38 | .55 | .71 | .71 | .71 | .71 | .71 | .71 | .80 | .80 |
| 1959 | .24 | .26 | .26 | .71 | .71 | .77 | .77 | .77 | .77 | .77 | .96 |

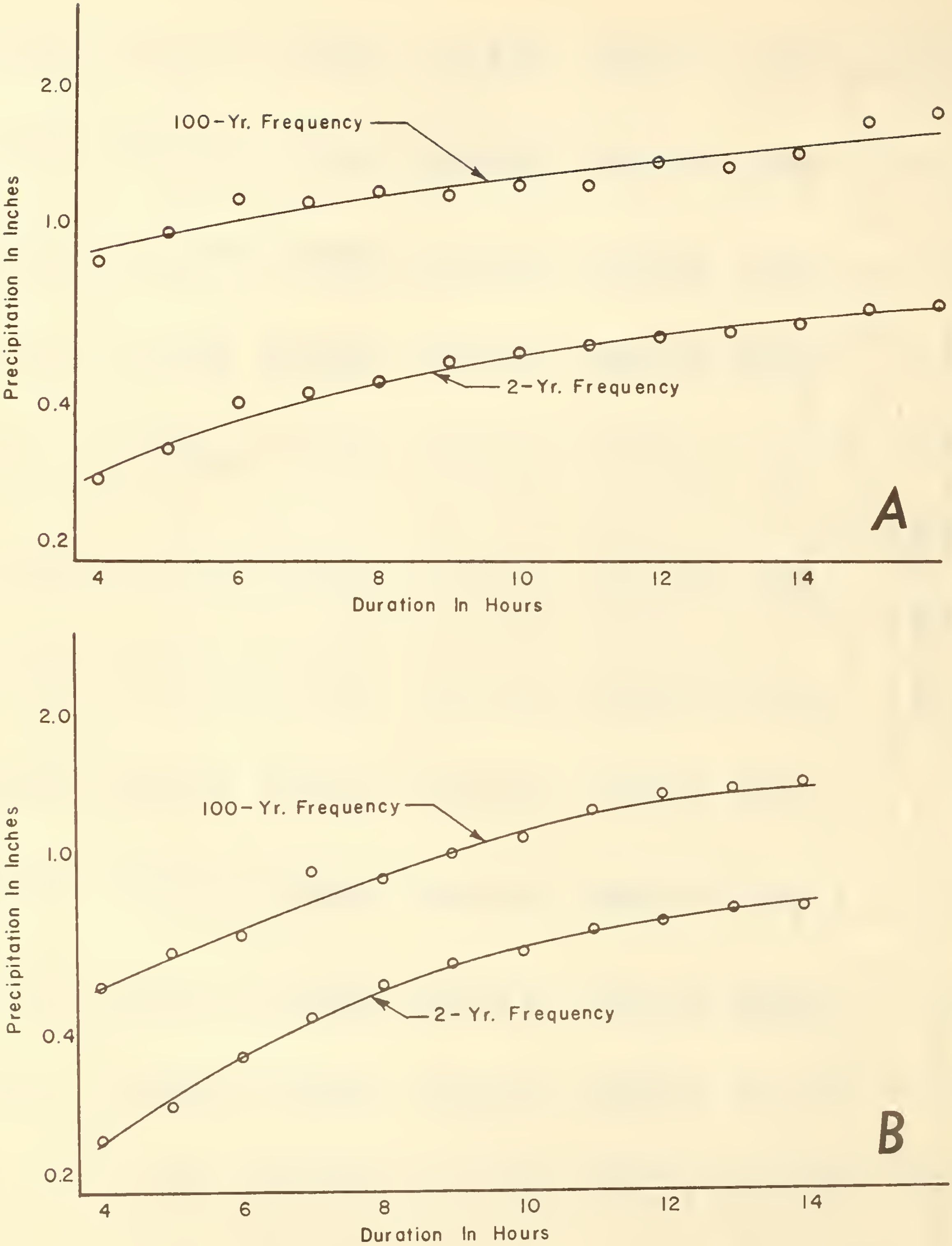

Figure 7.—Duration-precipitation amount A summer-type storms and B winter-type storms.

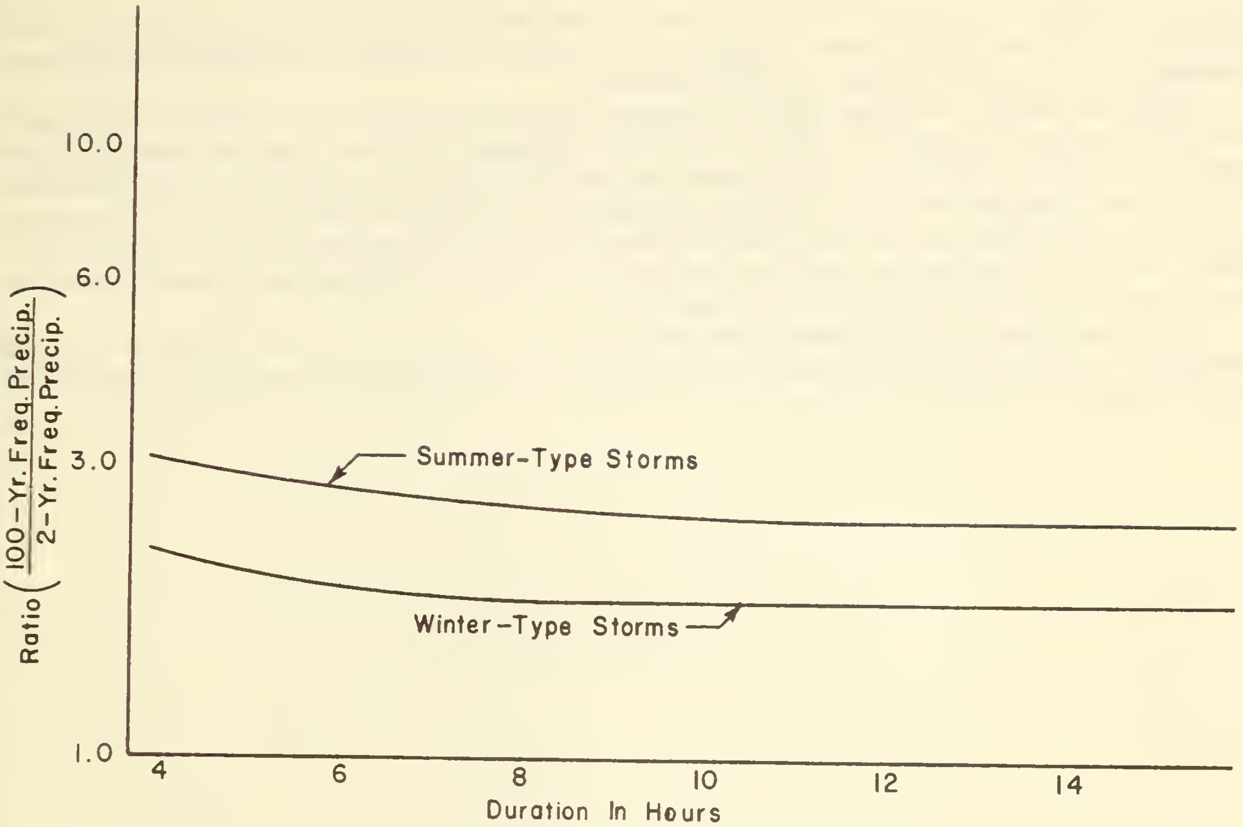

Figure 8.—Duration-frequency ratio.

slopes of the frequency curves reach a constant at about the 11-hour duration for summer-type storms and the 8-hour duration for the winter-type. After these durations are reached, the only change in the frequency curves is in the placement along a vertical axis of the Hazen graph paper.

## SUMMARY

Precipitation records collected in the Palouse area of Idaho and Washington were analyzed to determine: (1) the depth-time distribution, (2) the depth-area distribution, and (3) the depth-duration-frequency relations. Storms were arbitrarily separated into two types--those occurring from October through April were classified as "winter type" and those occurring May through September, as "summer type." Storms were further subdivided by the duration and the form of the precipitation. A storm was defined as a period of continuous precipitation immediately preceded and followed by a minimum of 3 hours during which no precipitation was recorded.

In the depth-time distribution the average summer-type storms were more variable than the average winter-type as shown by the wider spread between the upper and lower enveloping curves on figure 4 than on figure 5. "Advanced" and "delayed" storms were found in both the summer- and the winter-type.

Form of the precipitation had a greater influence on the depth-area distribution than did the season of the year in which the storm occurred. The average snowstorm had a more limited

areal coverage than did the average rainstorm. Also longer duration storms tended to be more uniform over the storm area. Apparently the amount of storm precipitation did not have a significant influence on the depth-area distribution.

Records from a rain gage that had been in continuous operation for 27 years were used in the depth-duration-frequency study. Slopes of the frequency curves of shorter duration storms were the steeper, which indicated greater variability in this group. As the duration increased, the slopes flattened until they reached a constant at 11 hours for summer-type storms and at 8 hours for winter-type. For any given duration, the slope the frequency curve of the summer-type storm was steeper than that for the winter-type. This was expected because of the variability of the summer convective thunderstorms.

This study was not an attempt to present extreme precipitation characteristics; it presents average characteristics. Individual storms may deviate widely from the average curves and for design work, this should be considered.

Growth Through Agricultural Progress